Formal and Informal Aspects of the Teacher Formation: An Open Distance-Learning Context for Educatinal Design on Simple Machines

F. Corni[1], *M. Michelini*[2]

Research Unit in Physics Education of the University of Udine
[1]*Physics Department, University of Modena and Reggio Emilia, Italy*
[2]*Physics Department, University of Udine, Italy*
e-mail: corni@unimo.it

Some qualitative and quantitative results of a joint research on educational path design by students of the degree courses in Primary Education of the Universities of Modena and Reggio Emilia and of Udine are analyzed and discussed. A model of blended activity has been developed and experimented; in particular, the web-supported joint activity about simple machines completing the training path and consisting in three phases (in-depth study of the assigned topic, search for experimental solutions and design of educational paths) is object of this paper.

1. Introduction

A solid and widespread scientific culture can be achieved if science education and in particular physics education start very early, together with the first experiments in observing and representing the world around, at nursery and primary school; therefore the teachers have to be formed for this task [1, 2].
Several studies on people's familiarity with physics report that it is scanty, often resulting from a reductionist teaching method, based on a synthesis of the main ideal laws offered as a basic set of knowledge which can be applied to any context [3]. Pre-service education and training of teachers, started in 1998 in many Italian universities more than eight years [4] after the law which had instituted it, is an opportunity that should not be missed, in order to offer the new generations of teachers a knowledge of physics which is solidly anchored to their professionalism, so as to be used it in children' education.
Educational design is one of the main professional skills [5], so an important issues to be dealt with in pre-service training is to provide the teachers with basic scientific culture which may enable them to perform successful educational design in spite of their limited knowledge of the subject. This paper reports about a joint research experiment on educational path design about simple machines carried out by researchers of the Universities of Modena and Reggio Emilia and of Udine within the degree courses in Primary Education.

2. Work context and synchronous cooperation

Research collaboration is ongoing, between teachers of the degree course in Education of the Universities of Udine and of Modena and Reggio Emilia, aimed at elaborating and testing new strategies and methodologies for the teaching of physics [6]. The experiment here reported was done in the academic year 2004-2005, when the courses of *Design of Educational Experiments* of the two university sites were carried out during the same period and according to the same syllabi, in order to enable the about 70 attending students to perform both face-to-face and distance synchronous interaction.

Both single-site and joint-site activities were carried out: the focus of this paper is on the last part of the intervention consisting in a network-supported distance cooperation between students of both sites to perform joint design of educational paths on simple machines.
The web-based environment used for the experimentation supplies a variety of tools, ranging from asynchronous communication tools such as web forums, internal messaging and *scricoll* (a tool for distance cooperative writing), to synchronous communication ones such as chats.
The reference materials for educational design (projects, cards, experiments, examples of school activities) made available to the students were produced in the course of several studies carried out in the field of scientific didactics and informal education [7] which can be found in the webpage www.fisica.uniud.it/URDF/.

3. Web-based work methodology

The task was organized into 3 consecutive phases. Phase I (11 days long) where the students analysed and discussed the physics concepts underlying simple machines by means of web forums; phase II (13 days long) dealt with the search for and discussion of experimental solutions starting from the students common experience and from the web resources available to them; and phase III (7 days long) where the students in groups designed educational paths by means of the *scricoll*. The scheme for drafting the paths was drawn from the one carried out within the SeCiF project [8]. The activities were attended on-line by a tutor who intervened in the process only to steer or correct the approach of the various phases.

4. Results

The quantitative analysis, based upon statistical data, on the quality of the web-supported cooperation has been described in a former paper [9]; only the elements necessary to the analysis of the formal and informal aspects of educational design on simple machines will be dealt with herein.

4.1 Phases I and II

During the first two phases of the activity the students performed individual on-line work, taking part into several discussions launched and managed by themselves in the web forum. Each student willing to propose a new topic was supposed to fix a title for the discussion and to write the first message; the participants could joint the discussion either by proposing further discussion threads (first-level messages) or by replying to messages belonging to existing threads on any level.
Phases I was attended by 76 students who launched 88 discussion topics - not all of them different from one another. A total number of 398 messages were sent (1.2 topics and 5.2 messages per student; 4.5 messages per topic). Phases II was attended by 69 students who launched 76 discussion topics - not all of them different from one another. A total number of 330 messages were sent (1.1 topics and 4.8 messages per student; 4.3 messages per topic).
The level of cooperation among students was good, as is shown by the ramification index [10] considering discussion topics containing more than 4 messages; therefore the qualitative analysis of the contents - performed by grouping the whole of the students' discussion topics into macro-topics - is to be considered significant.
As regards Phase I, the macro-topics contained in the messages exchanged by the students are relevant to three main categories: a) physics concepts (41%), i.e. force, torque, and equilibrium; b) simple machines in general (19%); c) different kinds of simple machines, i.e. levers, screws, and pulleys (40%). The topics were discussed by the students according to 4 main characteristics: 1) *formal definition*: mention of the relevant physical quantities and of

their connections; 2) *qualitative description* of relevant aspects (e.g. "a wheel and axle is made by a grooved wheel with a rope running over it"); 3) *classification* (e.g. the various lever classes); 4) *listing* (e.g. "levers of second class are: nutcrackers and wheelbarrows…").
Macro-topics concerning physics concepts are mainly introduced by means of the first two categories, using formal terms.

Table I

MACRO-TOPIC / **CHARACTER**	**FORCE**	**TORQUE**	**EQUILIBRIUM**	**SIMPLE MACHINES**	**LEVER**	**SCREW**	**PULLEY**
Definition	36%	80%	83%	52%	66%	27%	44%
Description	27%	20%	17%	26%	28%	64%	33%
Classification	N/A	N/A	17%	9%	24%	18%	44%
Listing	N/A	N/A	N/A	17%	31%	N/A	N/A

N/A _ not applicable

As can be seen in Table I, students tend to quote definitions rather than providing descriptions when dealing with unfamiliar concepts such as torque and equilibrium: it is as if they tried to seek refuge in ready-made expressions in order to shirk responsibilities and to avoid personal formulation of concepts, confining themselves to mere quotations of statements and showing no in-depth knowledge of their meaning (inert knowledge area). The concept of force, which is more familiar to students but requires deep critical comprehension skills bound up with a mental model, is dealt with in a descriptive way as well.
Students provide non-formal verbal definitions of simple machines, together with descriptions, classification and listing.
Messages exchanged by the students on the three kinds of simple machines are evenly distributed in the first three categories, with less formal and less exhaustive presentations which seldom refer to the physics concepts underlying their functioning. This reveals their difficulty in connecting formal learning – namely physics concepts – with commonly used everyday objects.
In Phase II (search for and discussion of experimental solutions) one can identify two main strands in the messages exchanged by the students: particular kinds of commonly used simple machines (74%), or educational activities addressed to children (26%).
The messages dealing with the 5 kinds of simple machines mentioned in the task assignment sheet (lever, wedge, pulley, inclined plane and screw) were classified as follows: 1) technical statements (T): the object is described in its parts; 2) physical statements (P): the physical quantities involved and the mathematical relations which guarantee equilibrium are mentioned, even though expressed in words; 3) didactical suggestions (D): activities are proposed (most of which of experimental kind) to enable children to acquaint themselves with simple machines; and 4) examples (E): examples of commonly used objects that can be traced back to models of simple machines are provided (see Table II).
The incidence of messages dealing with wedges having low statistical relevance, this kind of simple machine was ruled out from the analysis and comparison.
Levers are identified by students as commonly used everyday objects. Pulleys and screws are often described in their technical details due to their use in technological instruments. Finally, inclined planes are often described from the point of view of physics since they are often dealt with in physics courses in different contexts.

Table II

	T	P	D	E	Tot. messages
Lever	13%	14%	23%	51%	44%
Wedge	25%	0%	13%	63%	5%
Pulley	47%	12%	16%	26%	26%
Inclined plane	9%	35%	17%	39%	14%
Screw	44%	17%	6%	33%	11%

The educational activities proposed by the students definitely show that levers (88% of messages) are the most easily identifiable simple machines among commonly used everyday objects, and as such are the ones more frequently integrated into educational paths. Wedges receive no consideration, whereas screws, pulleys and inclined planes appear in 7%, 4% and 2% of messages respectively

4.2 Phase III

During Phase III the students worked divided into 8 spontaneously created groups varying from 2 to 13 students.

The educational paths produced appear to be globally (7 out of 8) coherent in their contents and homogeneous in style though they have been designed by several authors. Web-supported cooperation does not make design tasks heavier and favors the sharing of knowledge and competence.

An informal, entertaining and ludic context is the reference framework of all the educational paths produced during the experiment. The activities formerly performed raised the students' awareness on this issue, that does not emerge from educational design carried out with different methodologies [5]. Physics concepts re-emerge within the common-sense framework characterizing informal educational approaches. Mechanical equilibrium is often referred to as the avoiding of falling down of a body; weight is thought of as the only force to be counterbalanced; active force is referred to muscular strength and by focussing only on its intensity. Moreover, constraints are considered as physical points to be recognized as fulcrums, and forces applied to them are hardly ever recognized.

The analysis of the educational paths produced by the students led to the identification of 2 general types of paths which are paradigmatic of the educational approach by teachers undergoing pre-service training.

A. Pedagogic type: 4 paths out of 8. Good psycho-pedagogical grounding, including quotations from the best-known authors in the field, prevail on the contents. The activities proposed in these paths aim at enabling children to acquaint themselves with materials (various kinds of simple machines) and terminology (lever, fulcrum, equilibrium, inclined plane, etc.) or to instruct them in the use of simple machines (mechanical advantage of simple machines) as if science learning could result from children's interaction with reality and not from the teacher's supporting and guiding role towards the achievement of a conceptual objective.

B. Balanced type: 2 paths. The activities proposed by these groups show special care for the illustration of physical quantities and their correlation and for the support to be given to children' modelling skills through scale construction of models with commonly used materials and through discussion of the children's observations and of experimental data. Group work ranges from nursery school to the last year of primary school and goes deep into the theme of levers by means of a number of topics connected to one another in a circular approach, making a correct use of the prevision-experiment-comparison cycle.

Besides the abovementioned general types, 2 particular cases emerged from the 8 paths.

a. ***Passive case*** (group 7). The contents deal with only one specific topic; prerequisites are described in an imprecise and extremely general way; children's difficulties in learning are not ascribed to science concepts but to problems relevant to social, communication and context issues; educational proposals are uncritically quoted from textbooks and lesson notes. This reflects the students' attitude of shirking responsibilities: they do not feel the need of personal reworking and reflection upon the subject they are going to teach.

b. ***Incoherent case*** (group 2). The path shows an evident lack of integration and homogenization of the contributions provided by the group members probably due a lack of adequate discussion among the students and to a lack of concurrence of views prior to the joint design of the path.

5. Concluding remarks

Below are reported some points as guidelines for teachers' training activities to come.
Investigation on the physical concepts underlying the design of the educational paths has only inertly activated formal learning contexts. The competence applied to the design activity belong to scientific and operational contexts which however are kept separated from each other. The necessity to place learning in actual situations shifts attention from the general to the particular and from physical concepts to the single everyday objects. Search for experimental solutions appears to be correlated to the contents of Phase I only when the learning context is informal and particular. The operativeness of educational proposals acts as a bridge between physical concepts and their location in everyday-life contexts. Students who design learning activities for children act in the light of a physical concept which is clear to them and that they propose to children in ludic terms: the rules of the game are the rules of physics. The students' attitude is formal or informal according to the extent of their familiarity with the single topics. Mere web-supported discussion along the same thread does not enable students to overpass the boundaries of a single context; it is necessary to strengthen the motivations for overpassing such boundaries thanks to the support of a web tutor. On-line cooperation boosts the integration of different styles in dealing with the same subjects, thus allowing the design of coherent learning paths. The paths may become more specific thanks to a reflection upon the physics concepts underlying them (to be performed during Phases I and II).
The available resources are not effectively and autonomously retrieved by the students: the necessity emerges to support them in finding suitable documentation materials. It is to be remarked as a particularly impressive feature that, though they were provided with adequate reference materials, students still do research in the web or in books and publications in order to carry out the task.
Much research work is needed yet to study the ways to activate the links between disciplinary and professional competencies.

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Michelini M 2004 Physics in context for elementary teacher training *GIREP book of selected papers "Quality Development in the Teacher Education and Training"* (Forum, Udine) p 389

[4] he difficult task of starting pre-service education for teachers has been accompanied by a cultural debate documented since 1996 by the Journal Università e Scuola, edited by ConCURED (National Conference of the Education and Didactic University Research Centers) in cooperation with the University of Udine. The abstracts can be consulted on the Web site www.uniud.it/cird/
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[8] SeCiF - Studiare e Capire in Fisica (Studying and Understanding Physics), a PRIN project in which 9 universities took part, aimed at producing educational projects for the teaching of Physics. The materials produced by Udine University are available under the SeCiF icon at the page: www.fisica.uniud.it/URDF/.
Items of the scheme: Introduction (remarks on the educational, methodological and scientific assumptions); Methodological layout; Approach; Strategies and methodologies; Prerequisites; Conceptual/organizational map; Thread (educational path, sequence); Activities to perform; Conceptual cruces and learning challenges; Educational tools.
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